A METHOD AND A SYSTEM FOR PURIFYING WATER

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Cited documents:

- WO9611170
- DK286789
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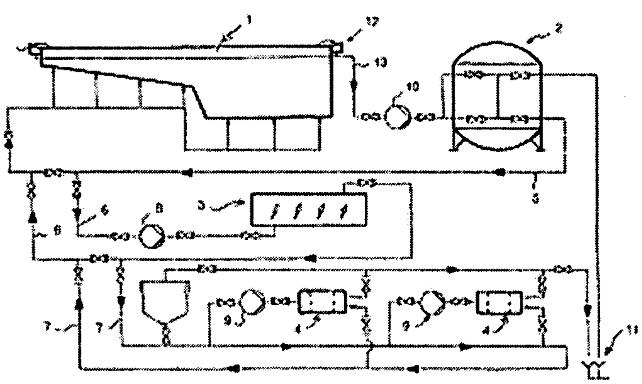
- US4372860
- JP7195097

Abstract of **WO9933752**

The invention provides a method and a system of purifying water, in particular chlorinated bathing water in a swimming pool (1), by circulating the water through a filter device (2) for filtration of the water, and then at least a subflow (6) of the filtered water on the clean water side of the filter device is passed through a UV system (3) for photochemical treatment, wherein this first subflow (6) is irradiated intensively with electromagnetic radiation from one or more metal dosed UV intermediate pressure lamps during the passage through the UV system, and then a second subflow (7) of photochemically treated water is withdrawn from the first subflow (6) for nanofiltration or reverse osmosis treatment in a membrane filter device (4). With the present invention it is now possible also to remove carcinogenic substances, such as THM and AOX from the bathing water in swimming pools or the like. It is moreover realized by the invention that a method according to the invention may also be used for removing biocides, pesticides and peroxides, which makes the method according to the invention suitable for purification of water to produce drinking water.



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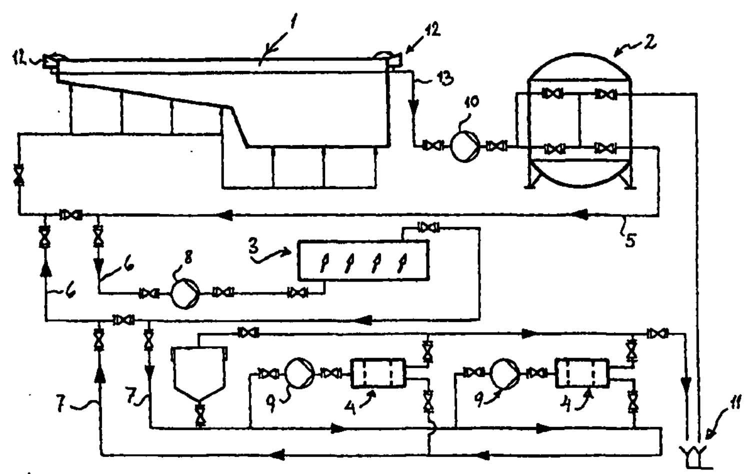

(57) Abstract

The invention provides a method and a system of purifying water, in particular chlorinated bathing water in a swimming pool (1), by circulating the water through a filter device (2) for filtration of the water, and then at least a subflow (6) of the filtered water on the clean water side of the filter device is passed through a UV system (3) for photochemical treatment, wherein this first subflow (6) is irradiated intensively with electromagnetic radiation from one or more metal dosed UV intermediate pressure lamps during the passage through the UV system, and then a second subflow (7) of photochemically treated water is withdrawn from the first subflow (6) for nanofiltration or reverse osmosis treatment in a membrane filter device (4). With the present invention it is now possible also to remove carcinogenic substances, such as THM and AOX from the bathing water in swimming pools or the like. It is moreover realized by the invention that a method according to the invention may also be used for removing biocides, pesticides and peroxides, which makes the method according to the invention suitable for purification of water to produce drinking water.

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A method and a system for purifying water

The present invention relates to a method of purifying water, in particular chlorinated bathing water in a swimming pool, by circulating the water through a filter device for filtration of the water, and then at least a subflow of the filtered water on the clean water side of the filter device is passed through a UV system for photochemical treatment. The invention moreover relates to a system for purifying water by performing such a method.

In e.g. swimming pools, chlorine is added to the bathing water as a disinfectant. This, however, causes formation of bound chlorine in the form of e.g. nitrogen-bound chloramines, which give obnoxious smells as well as irritation of eyes, mucosae and skin, just as these substances may constitute a health hazard for the bathers. DK-B-144 663 discloses a method of removing chloramines from chlorinated water in swimming pools by intensive irradiation of the water with ultraviolet light at a wavelength of $\lambda > 300$ nm.

It has moreover been found, however, that the addition of chlorine to bathing water causes formation of THM (Trihalomethanes) and AOX (Adsorbable Organic Halogens), both of which are a generic name for substances of which most are carcinogenic. This is a problem particularly in swimming pools, since both THM and AOX are odourless substances and do not give the irritations known from the chloramines. This means that the bathers do not discover the presence of the substances. The photochemical method according to DK-B-144 663 does not remove THM and AOX in sufficiently large amounts for the occurrence of the substances to be reduced in the swimming bath.

It has been known for some years that THM is formed in chlorinated bathing water, and some countries have fixed limit values for THM. To reduce the amount of both THM and chloramines in bathing water, the art comprises a method where active carbon is dosed on the top of a sand filter which is installed to purify the water. The sand filter, which per se does not remove the chloramines and the THM substances, thereby also filters these substances in addition to particles and suspended solids in the bathing water.

Owing to the dosing of active carbon, this method, however, creates problems when the sand filter is backwashed, which must be carried out almost every second day. This active carbon turns into large amounts of sludge that have to be disposed of, which is a problem, since, at several places, it is forbidden to flush active carbon out into the sewer. Moreover, this method involves the risk that bacteria are formed within the sand filter.

In this method, however, sufficient AOX is not removed, and since AOX occurs in about 10-15 times larger amounts than THM, this constitutes a health problem. With respect to the fixing of limit values of AOX, it is a predicament that today no certain and economic method of removing AOX is known, but, mostly, the concentration in the bathing water is reduced by dilution with make-up water in which AOS is formed in smaller amounts than in chlorinated bathing water.

Generally, this method of reducing the concentration of both the chloramines, THM and AOX is unacceptable, since at most places drinking water is used as a dilution solution to the problems of too high concentrations.

Furthermore, drinking water is usually used for backwashing the sand filters. Particularly when the sand filter is dosed with active carbon, it must frequently be backwashed. Thus, enormous amounts of drinking water are used for the purification process, which makes the purification process extremely costly, in addition to the fact that it is a waste of resources to use drinking water for this purpose.

Accordingly, the object of the invention is to provide a method and an associated system which are capable of removing both bound chlorine (chloramines), THM and AOX from the water, just as the invention is intended to provide a method and a system which are resource-saving in use.

The invention comprises irradiating the first subflow intensively with electromagnetic radiation from one or more UV lamps during the passage through the UV system for photochemical pre-treatment of the water, and then withdrawing a second subflow of photochemically treated water from the first subflow for filtration by nanofiltration or reverse osmosis treatment in a membrane filter device. The invention moreover comprises a system for performing the method, said system comprising a filter device, such as a sand filter which is connected with a pipe string on the clean water side, a first substring being branched from said pipe string, said first substring having arranged therein a UV system for photochemical treatment of the first subflow, a second substring being branched from the first substring, said second substring having arranged therein one or more membrane filters for removing compounds (inter alia AOX, THM, salts) truly dissolved in the water.

The invention provides a method of water purification whereby both THM (Trihalomethanes), chloramines, AOX (Adsorbable Organic Halogens) may be removed from the water which is filtered through the filter device, which is preferably a sand filter.

It is hereby possible to remove the carcinogenic substances from the bathing water in swimming pools or the like. It is moreover realized by the invention that a method according to the invention may also be used for removing biocides, pesticides and peroxides, which makes the method according to the invention suitable for purification of water to produce drinking water, e.g. from polluted groundwater.

Also achieved are a method and a system in which the intervals between the backwashings of the sand filter is prolonged considerably, so that even highly loaded swimming baths only have to be backwashed once a week at a maximum. This results in a great saving of water.

The branching of the second subflow after the water has been treated photochemically means that the water in the second subflow is free of active chlorine, chloramines and part of the THM and AOX which the photochemical process can degrade. The water is thus without oxidation substances which would otherwise destroy the membrane filters, which is the next step according to the invention. The oxidation substances are activated in the UV system, which causes them to be degraded, the degradation taking place via the formation of $OH^{\bullet}$ (radical), which is the strongest ion in water for oxidation. Extremely clean water is achieved hereby.

In a preferred embodiment of the invention, the first subflow is irradiated with energy-rich electromagnetic

radiation in selective wavelengths, which essentially correspond to the value of the absorption energy level for each of the contaminants in the water, such as e.g. chloramines and similar chlororganic compounds. According to this preferred embodiment the UV system is a reaction container with one or more metal halide vapour lamps, which are dosed with one or more metals, for emission of electromagnetic radiation in the selective wavelengths. This provides an energy-saving UV photochemical treatment, as the lamp type may be arranged to preferably emit electromagnetic radiation in the form of ultraviolet light in precisely the wavelengths which correspond to the undesired chemical compounds in the water.

One or more of the UV lamps, which are preferably metal halide intermediate pressure lamps, are arranged at the inlet and outlet pipes of the reaction container. This results in a simple structure of a reaction container for the UV system. The lamp or lamps are positioned in such a way that the water has a sufficient residence time relatively to the energy of the lamp and the turbidity of the water. In case of two or more lamps, the lamps are also distributed relatively to the circumference, when the lamps are arranged at the ends of the reaction containers. When mounting the lamps longitudinally of the reaction containers, the lamps are divided in relation to the length of the reaction container.

The photochemically treated water is pumped through at least one or more membrane filters for nanofiltration or reverse osmosis treatment, and the water is pumped actively through each membrane filter, a pump being arranged before each filter. By, according to this embodiment, withdrawing the second subflow and using a membrane filter after the water has been photochemically purified, it is ensured that the membrane filter just has to remove

THM and AOX as well as biocides, pesticides and peroxides, if any, as the chloramines have already been decomposed. This means that the membrane filter can operate at a relatively low pressure of about 7 to 15 bars against about 60 bars, if also the chlorine-bound substances were to be removed, which results in an extremely long service life of the membrane filter. Thus a service life of 3-5 years may be expected against the normal 6-8 months. This is achieved also because the water pressed through the membrane filter is filtered water having a particle size of below 1-1.5 µm. Most loading substances for the filter system used are minimized because of the sand filtration and because of the $OH^{\bullet}$ (radical) ion.

The invention will be described more fully below with reference to the accompanying drawing, in which the figure shows a diagram of a filtration system according to the invention for filtration of bathing water in a swimming pool.

The figure shows a swimming pool 1 from which the bathing water runs out into an overflow channel 12 and out into the purification system. The water is pumped from the overflow channel 12 through a pipe 13 into a sand filter 2, a feed pump 10 being inserted in the pipe 13. This feed pump 10 is adapted to the capacity of the sand filter 2 and typically has a capacity of about 250 m^3 per hour in a typical combination swimming bath of 25 x 16 m for non-swimmers and swimmers.

The filtered water is conducted from the clean water side of the sand filter 2 through a pipe string 5 back into the pool 1. A first substring 6 is branched from this pipe string 5, and a subflow is withdrawn from the pipe string 5 for photochemical treatment. A UV system 3 is inserted in this substring 6 for photochemical treatment

of the fed filtered water from the sand filter 2. The subflow constitutes about 20% of the filtered water in the return string 5 to the pool 1. The size of the subflow is regulated by suitable valve devices. The water is pumped through the UV system 3 by a pump 8 which is inserted in the first substring 6, the capacity of the pump being adapted to the capacity of the UV filter 3. This capacity is 50 m^3 per hour in a preferred embodiment of a combination bath of 25 x 16 m.

The UV system 3 degrades the active chlorine, the nitrogen-bound chlorine (chloramines) and only a little of the organic bound chlorine (THM and AOX) which are present in the filtered water. The UV system comprises a reaction container in which at least one UV metal halide lamp is arranged both in the inlet and in the outlet in the container. The photochemical lamps are all of the same type, which means that it is not necessary to stock many different types at each installation site. According to the invention, the lamp type is an intermediate pressure lamp, which is a special metal halide vapour lamp dosed with various metals in such a way that the lamp has as much energy as possible in the wavelengths which are necessary for the photochemical process. These wavelengths depend on the substances which are to be removed, and with the preferred lamp type it is possible to select the wavelengths which correspond to the absorption level of the undesired substances which are dissolved in the water. These wavelengths of electromagnetic radiation or UV light will typically be of the order of $\lambda \approx 190\text{-}465$ nm, but may also be outside this range if so called for by the absorption characteristic of the undesired substances.

After the water has been treated photochemically, a second subflow is withdrawn from the first substring 6 in a

second substring 7. The amount withdrawn from the first subflow must not be larger than necessary to maintain equilibrium in the pool 1. It will preferably be about 10-15% of the first subflow when a 25 x 16 m combination bath is involved.

This second substring 7 has inserted therein a membrane filter 4 and a suitable arrangement of valve units for controlling the flow in the strings 6, 7. In the embodiment shown, two membrane filters 4 are arranged in series with their respective pumps 9 arranged immediately before the filter 4. These pumps 9 are selected to give a pressure of about 15 bars and have a capacity which corresponds to the associated membrane filter 4, and which is preferably about 3.75 m^3 per hour. The water is passed through a membrane filter, whereby a reverse osmosis treatment takes place. With the lower pressure for reverse osmosis systems (only about 7 to 15 bars against the usual about 60 bars), the membrane filters have a considerably longer service life, just as a low current consumption is obtained.

Alternatively, the two membrane filters may be arranged in parallel and optionally have a common pump. Moreover, as another alternative, it may be possible to arrange a single membrane filter 9 in the substring 7, if conditions so permit, such as e.g. in a purification system for smaller pools.

The membrane filters 9 are connected with an outlet 11 where the filtered concentrate is discharged.

The water is first filtered in the sand filter 2, whereby inter alia suspended solids and other particles larger than 1-1.5 µm are filtered. Then a subflow of this filtered water is treated photochemically to degrade the

chlorine-related substances in the water, which is followed by the withdrawal of a further subflow which is subjected to a reverse osmosis process to filtrate the "true" solutions in the water, thereby removing the carcinogenic substances THM and AOX from the water. The water is then passed back to the pool. A method and a system for purifying swimming bath water are obtained hereby, wherein dilution is no longer the only answer to the problems of reducing the concentrations of the undesired substances, be it the chloramines and the other chlorine compounds, THM and AOX, below the desired levels of concentration, such as the limit values to the extent to which such exist.

P a t e n t   C l a i m s :

1. A method of purifying water, in particular chlorinated bathing water in a swimming pool (1), by circulating the water through a filter device (2) for filtration of the water, and then at least a subflow (6) of the filtered water on the clean water side of the filter device is passed through a UV system (3) for photochemical treatment, c h a r a c t e r i z e d in that this subflow (6) is irradiated intensively with electromagnetic radiation from one or more UV lamps during the passage through the UV system, and then a second subflow of photochemically treated water is withdrawn from the first subflow for nanofiltration or reverse osmosis treatment in a membrane filter device (4).

2. A method according to claim 1, c h a r a c t e r i z e d in that the first subflow (6) is irradiated with energy-rich electromagnetic radiation in selective wavelengths, which essentially correspond to the value of the absorption energy level for each of the contaminants in the water, such as e.g. chloramines and similar chlororganic compounds.

3. A method according to claim 1 or 2, c h a r a c t e r i z e d in that the photochemically treated water is pumped through at least one or more membrane filters (4) for reverse osmosis treatment or nanofiltration, and that the water is pumped actively through each membrane filter (4), a pump (9) being arranged before each filter.

4. A method according to any preceding claim, c h a r a c t e r i z e d in that the first subflow (6) constitutes about 20% of the filter capacity of the filter device.

5. A method according to any preceding claim, c h a r a c t e r i z e d in that the second subflow (7) constitutes about 10-15% of the first subflow (6) of photochemically treated water.

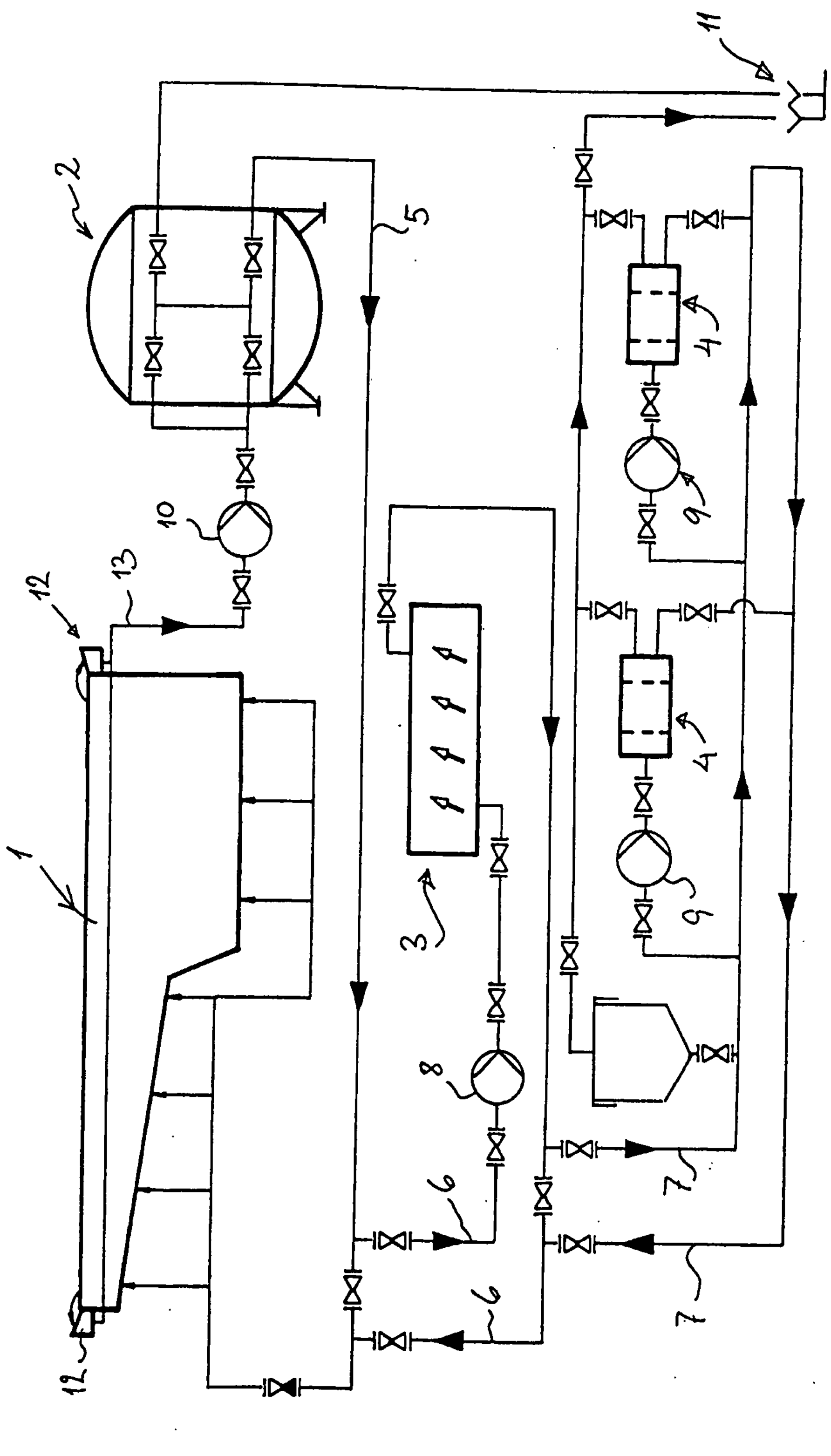
6. A system for purifying water by performing a method according to any preceding claim, c h a r a c t e r i z e d in that the system comprises a filter device, such as a sand filter (2), which is connected with a pipe string (5) on the clean water side, a first substring (6) being branched from said pipe string, said first substring having arranged therein a UV system (3) for photochemical treatment of the first subflow, a second substring (7) being branched from the first substring, said second substring having arranged therein one or more membrane filters (4) for removing compounds dissolved in the water, such as THM, AOX and/or salts.

7. A system according to claim 6, c h a r a c t e r i z e d in that the UV system (3) is a reaction container with one or more meal halide vapour lamps, dosed with one or more metals, for emission of electromagnetic radiation in selective wavelengths, which essentially correspond to the value of the absorption energy level for each of the contaminants in the water, such as e.g. chloramines and similar chlororganic compounds.

8. A system according to claim 7, c h a r a c t e r i z e d in that one or more of the UV lamps are metal halide intermediate pressure lamps.

9. A system according to claim 7 or 8, c h a r a c t e r i z e d in that at least one lamp is arranged at the inlet and outlet pipes in the reaction container.

10. A system according to any one of claims 6-9, c h a r a c t e r i z e d in that the second substring (7) has two serially arranged membrane filters (4), and that a pump (9) is arranged in connection with each membrane filter.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INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 98/00584

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C02F 9/00, C02F 1/32, C02F 1/44
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 April 1999	20 -04- 1999
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 98/00584

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

02/03/99

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